

Philosophy vol 2.
AN
EXPLICATION
OF THE
FIRST CAUSES
OF
Action in MATTER;
AND OF THE
CAUSE
OF
GRAVITATION.

By CADWALLADER COLDEN.

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COLLADORE

PRINTED BY





T O
JAMES ALEXANDER, *Esq*;
A T
NEW - Y O R K,

S I R,

YOU have obliged me exceedingly by the trouble and care you have taken in examining the papers I sent to you, for that purpose. You will now find the number of lines in several places considerably increased; because I find it difficult to convey new conceptions of things to others, with that conciseness I at first intended, and which require a method of thinking entirely different from that, which, perhaps, has become habitual to them: but I must have been tedious

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if

if I had not left some steps to be supplied by the reader. For the same reason, I have not followed a method strictly mathematical, but such as I thought would more easily lead the mind of the reader, step by step, into the same conceptions I have. An adequate idea of any complicated matter cannot at once be formed; and therefore the difficulties which may arise in the first steps, cannot be easily removed, till the conception of the whole matter is cleared up by going further on. I have likewise, in several steps, taken different methods of conveying and clearing up the same conception: because the same man at different times, and different men at all times, receive any idea more easily in one way than in another.

THE design of these papers is so exceeding hardy, that I have all the reason in the world to be diffident of myself. To attempt to establish new principles in physics, different from those of all writers before me; to attempt to explain the cause of gravitation, after all the great men in philosophy have failed, and after *sr* ISAAC NEWTON stopt short, as at an enquiry not surmountable by his sagacity, which had discovered so many wonders: when I consider this, I have reason to fear, that this attempt will not only be blamed, as bold and rash, but will be look'd on as so vain and foolish, as not to deserve a reading, or any consideration. However, after having for a considerable time
revolved

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revolved it in my mind, and considered every objection which occur'd to me, with all the care and impartiality that I am capable of; the truth of the principles which I now advance, still appear with so much evidence to me, that I can no longer doubt of their certainty. Tho' I may not pretend to have acquired a perfect and adequate conception of what I treat, or that I have fallen upon the best method of conveying to others, the conceptions which I have formed myself, on this subject; the force of the evidence on my mind, is as strong as that of day-light after the sun is up in cloudy weather.

IF the subject of the following sheets were a mere piece of curiosity, in an abstruse point; it will even as such (if well performed) be very acceptable to curious men: but it has likewise opened to me, a prospect of great improvement in all the useful sciences in human life. I expect that not only sir ISAAC NEWTON's theorems, in his Principia, may be explained more easily from these principles, without the assistance of the conic sections; but that more easy and certain methods may be found for determining the orbits of the planets, and even of the moon, and of forming equations for that purpose, than can be done from other principles. Of how great consequence this may be in geography and navigation, they best know, who think that no method for discovering longitude
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at sea, can succeed, till the moon's place can be determined at all times with sufficient exactness. It gives me likewise a prospect of improvement in several other parts of physics. Upon the whole then, the evidence of truth, and the usefulness of the subject of the following sheets, as they appear to me, I hope will gain a favourable construction of my intention in printing only so many copies of them, as may be sufficient to submit my thoughts to the examination of the learned; and without any design of troubling the world any further on this subject, but according to the reception these sheets shall have with proper judges.

I have likewise another reason for my printing in the manner I do, that as I think these discoveries certain and useful, I would not have them lost to the world. I am grown old; I am not so much at ease as is necessary to prosecute such studies to any length, and I want many things necessary for this purpose: these, then, may serve as hints to others of much greater abilities than I can pretend to: and though what I have done, be not sufficient to set the truth in a clear light; others may be able to clear it of those obscurities, that I have not been able to remove. I have already gone so far, as to apply these principles to several phænomena and cases in gravitation: but I shall stop short in this publication, with finishing the sheet,
where

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where the explication of gravitation in general ends, till I shall know the judgment of others; and then, if I find it will be acceptable, I may add as far as my time and capacity shall allow me to proceed,

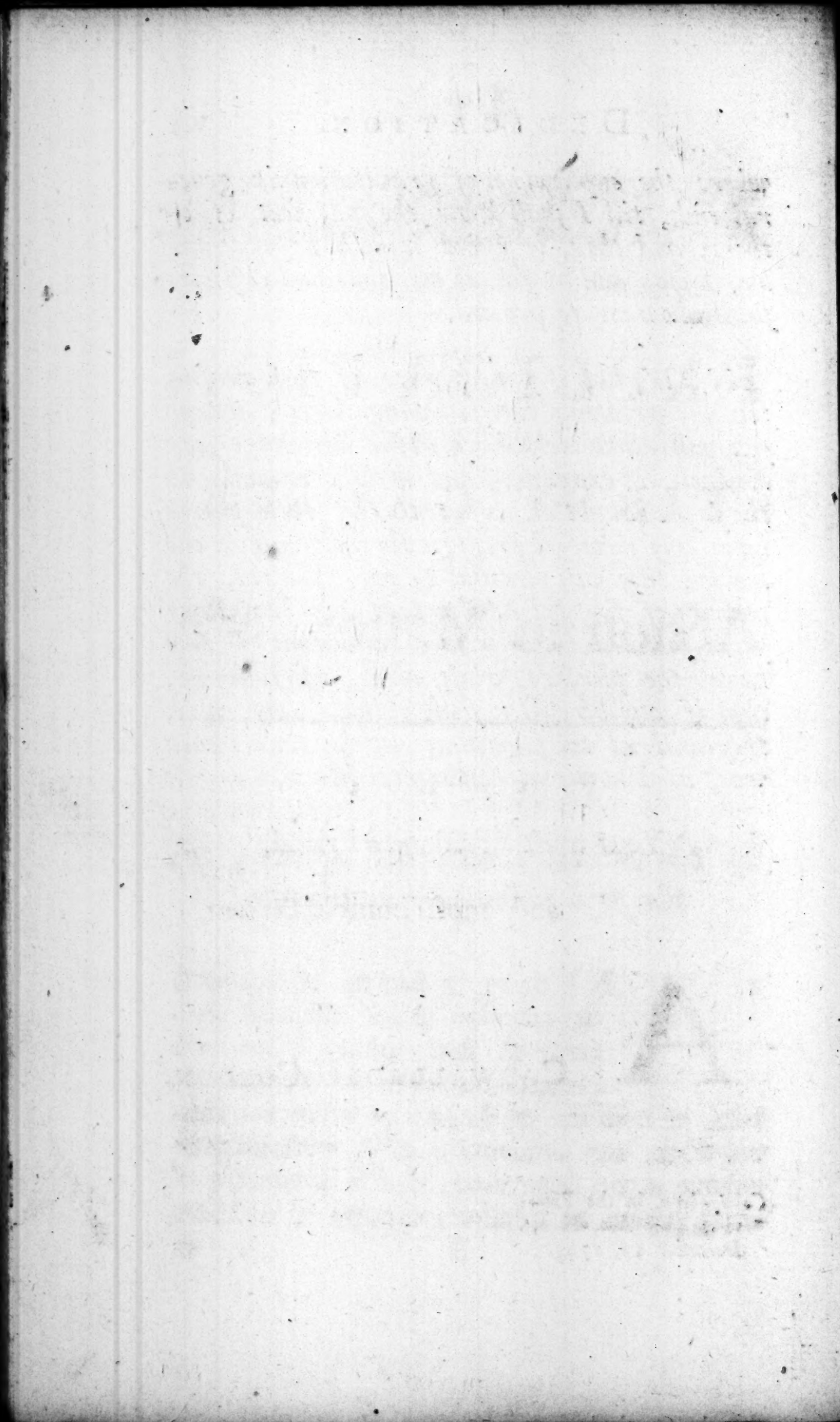
NOW, sir, if you approve of these reasons for my printing the following sheets; I hope you will allow me publickly to acknowledge your kindness, in examining and making remarks, on the first draught of them: that if these papers have any merit to preserve themselves from oblivion; they may continue to our children, the memory of the friendship that has for many years subsisted between us; and that I may have the pleasure while alive, of fancying, that if any hereafter shall think of my name, they will at the same time believe, that I ever was, as I now am, with great esteem,

Your most affectionate Friend,

and most humble Servant,

CADWALLADER COLDEN.

*Coldenham, in the Province of New-York,
December 13, 1745.*





A N
EXPLICATION
OF THE
FIRST CAUSES
OF
Action in Matter, &c.

C H A P. I.

*Of the primary material agents ; or,
the first principles in physics.*

I. **A**NY thing is said to be *extended*,
or *extension* is an essential pro-
perty of that thing, when we
cannot conceive it without li-
mits, or bounds, or shape ; or when we can-
not form any conception of it, without per-
ceiving at the same time, that it is capable of
being greater or smaller ; capable of addition
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or division, as consisting of parts, or as being divisible into parts : for that property is essential to any thing, without which we cannot form any conception of that thing. Therefore,

2. Every thing conceived as quantity, is *extended*.

3. A thing is said to be *impenetrable*, when it excludes every thing else from the space which it occupies. Every thing, which we conceive as distinct from another, necessarily includes this property : for the moment that we suppose, that two things absolutely occupy the same space, all distinction ceases in our conception of them ; and therefore the one or other, as to us, becomes a non-entity, or that of which we have no conception.

4. Every thing, which is conceived as *extended* and *impenetrable*, I call *Matter*.

5. Then if matter be taken in this large sense of the word, which, I think, is the common acceptation of it ; we must allow that there are different kinds or species of matter, distinguished by manifest essential properties, peculiar to each sort, and inconsistent with the essential properties of the others : which I propose to shew more particularly by what follows.

6. There is some thing endowed with a certain kind of force or power, by which it resists every alteration of its present state, whether it be in motion or at rest : this is commonly called, the *power of resistance*, and by

by sir ISAAC NEWTON, *vis inertiae*. There can be no doubt of something possessing this property, or that is endowed with this power or force: for it is so generally observed in every thing, which is the object of our sensations, that this power is generally attributed to all matter. But how truly this is done, will better appear after we have considered the nature of this power; which however will not be found easy for us to do, separately from other species of matter: because all the ideas we form of power, or force, or of action, are generally taken from matter in motion; and therefore we cannot easily conceive any action without motion. Yet it is evident, that motion ought by no means to enter into our conception of this power of resisting; for it exerts its force at rest as well as in motion.

7. In order to form an adequate notion of this power or force, I shall observe, 1. That this power or force cannot proceed from a meer want of action: for the power of resisting is sometimes greater, at other times less; sometimes it is able to resist a greater force, at other times only a less: but a meer want can never be greater or less; it is a non-entity, and cannot be of any quantity either great or small: it can have no power or force; for it is a negation of all power or force. 2. No kind of motion can enter into the conception of the manner of action in the power: for in the idea of motion we must con-

ceive some kind of tendency or direction from one place or point towards another place or point. If then the idea of resisting has any thing in common with motion, it must oppose motion more in one direction than in another, more when the motion which it opposes is in an opposite direction to the direction of resistance, than when both directions tend the same way: but resistance opposes motion in all directions; therefore nothing of motion can properly enter into the conception of it. 3. This power equally exerts its force, whether it be in motion or at rest: for when two quantities of this resisting power are different while at rest, the one greater than the other; if they be put in motion, that quantity which resisted most while at rest, will likewise resist most while in motion. 4. The effects of this power appear in a kind of obstinacy, by which it opposes all other power or force. It does not destroy the opposite power, but only opposes its action, and in some cases (as will be shewn afterwards) continues the effect of action of the other powers, which would otherwise cease. Neither can the power or force of resisting be destroyed by an opposite power: for if this power be essential to any thing, (as we shall afterwards prove) it cannot be destroyed without annihilating the thing itself. 5. This power, and every part of it, or particle, exerts its force or action in all directions: for it, and every part of it, equally opposes,

opposes, resists or lessens the action of other powers, in whatever direction they be applied.

6. The thing or being which exerts this power or force, is truly an agent; it is a principle which acts of itself, without the force, power or agency of any other thing: for, since its whole power or force is exerted in opposing the actions of all other power or force, it cannot receive its power or force from that which it opposes. Therefore,

8. The thing endowed with the power of resistance, or *vis inertiae*, is an agent, or active substance, subsistence, existence, or being, endowed with a certain power or force, whereby it persists in its present state, and opposes or resists all other power that would change that state, whether it be in motion or at rest; and thereby weakens, or renders more or less ineffectual, the action of all other power or force: which force it exerts in a manner peculiar to itself, and different from all other natural agents. Force without action, is a contradiction in terms; yet we are so accustomed to join motion with all action, that I find it very difficult to convey any notion of action or agency in the power of resisting, tho' it demonstrably be an agent or acting principle.

9. This power of resisting, or *vis inertiae*, may be considered as quantity: for it is every day, and in all places, observed to be greater or less: It is capable of being augmented or lessened; of consequence it is contained with-
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in some bounds or limits: it is of some shape, parts may be taken from it, or added to it, that is, it is extended. Indeed we can form no conception of it, without conceiving it as existing within some bounds or other: and therefore extension is essential to the agent exerting this power.

10. Again, it is impossible to conceive this power of resisting, without supposing at the same time, that this agent is *impenetrable*; that no other power can at the same time possess the same place: for as this agent acts by resisting other power or force; the thing which it resists must occupy a different place, otherwise we cannot conceive the one as resisting the other: therefore *impenetrability* is an essential property of the resisting agent: And of consequence,

11. The agent endowed with, or exerting the power or force of resisting, is a species of matter. There is no great difficulty of forming a conception of this agent, as a species of matter, or as being extended and impenetrable; every object of our senses round us, raises this idea in our mind: but I have taken this method of proving it, the more easily to apply this reasoning to some other agents, which we are not accustomed to consider in this manner.

12. It is generally concluded, that the force of resistance is in proportion to the quantity of matter resisting: because a greater quantity of resisting matter, requires a greater force to
move

move it. But it must be observed, that in considering this resisting matter, there are two different ways of considering it as quantity : either the quantity of extension (its bulk) or the quantity of its force. When we say two powers producing the same effect are equal, we then mean only as to the quantity of force; but two different quantities may have the same force : there may therefore be different species of this resisting matter, in which the proportions of their force to their bulk may be different; and, as these different proportions may be infinite in number, the different species of resisting matter may be infinitely different. No experiment, which only determines the force of two different agents to be equal, does, for that reason, determine that their bulk is so likewise. From sir ISAAC NEWTON's discovery of the infinitely different species of light, it is possible there may be as many different species of resisting matter ; and if there be, we may hope that a method may be discovered to demonstrate this. Before sir ISAAC's discovery, light was universally thought to be homogeneous ; and yet he has so clearly demonstrated the contrary, that none can doubt of its being the very reverse, that it consists of an infinite variety of species. Could any man have imagined, that this discovery, which had avoided all the curious researches of philosophers to his day, was made by so simple and common a contrivance, as a triangular glass-prism? Glass and prisms
had

had been known and in use many ages, and in all that time it was never imagined that any such discovery could be made: who then can say what discoveries may be made, when such another genius as sir ISAAC NEWTON's shall appear in the world?

13. We daily observe, that some things move, or pass from one place to another: the power of resisting is so very different from that of moving, that they can in no manner be conceived as the effects of the same agent, or of the same cause. We every day observe, that some things in motion, lose their motion; that the same things again, or other things at rest acquire motion, and things moving with small velocity acquire greater velocity: this motion then must either be by some power, force or agency in the moving thing itself, or it must be the effect of some other power without it: this other thing must be of itself an agent, and has the power of moving essential to it; or it must be put in motion by a third thing, and so on; we must then at last rest in something to which the power of moving is essential, or we must allow, that an effect can be produced without a cause: this thing then, to which motion is essential, which moves by its own natural force, must be an agent, which has its active principle in itself.

14. We every day perceive different quantities of motion, or its force or power sometimes greater, sometimes less, and we perceive

ceive it in different places : we cannot then otherwise conceive it than as bounded, or of some shape, and as consisting of parts ; and therefore extension is essential to the idea thereof. We every day likewise see resisting matter put in motion by this agent ; therefore they must be impenetrable to each other : for otherwise we cannot conceive the one as moving, the other as resisting ; neither can we otherwise conceive them as distinct beings, without distinct places. This moving agent, or this thing endowed with the power of moving, is a species of matter. When we see a small spark gradually set a large city all in a blaze, can any man imagine that there is no more motion in all the parts of the city, thus on fire together, than there was in the first little spark that began the fire ? That there is no more power or force in this prodigious fire, than there was in the scarce distinguishable spark which began it ? But if there be not supposed something mixed in the materials of the city thus on fire, which has a power of moving of itself ; all the prodigious force of motion in the city thus on fire, must be supposed in the first little spark which began the fire : for nothing can give what it has not. There are innumerable other Phenomena, which evidently shew, that some parts of matter are self-moving agents, and which ever move, unless hindered by the superior force of resisting matter ; and that as soon as the resisting power is by any means re-

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moved,

moved, the self-moving matter immediately recovers its motion.

15. Since the resisting and moving agents are so very contrary to each other in their nature, resisting motion and self-moving, that it is impossible to conceive them as existing in the same thing, or that any one thing can have both powers essential to it; we must then be very careful not to attribute these different powers, and inconsistent modes of action to the same agent: which however, from what follows, it will appear, is not easy for us to avoid.

16. Suppose that two quantities of the moving agent, or two particles of moving matter (for both these expressions signify the same thing) move towards each other with the same force, in opposite directions, what will happen after their meeting? If you say, that they will stop each other, and remain at rest; I deny it; because motion never destroys motion, or lessens it: it is the property of resisting matter only to stop, lessen, or render ineffectual the force of the moving matter. I shall ask, what is it in the opposite motions which destroys motion? If you say, that it is their mutual resistance; I answer, they have no resistance. I have proved (7, 8, 13, 14, 15,) that the power of resisting and moving, can never exist in the same agent; and therefore two particles of moving matter cannot, in the proper sense of the word, resist each other's motion.
What

What then, you'll say, must happen after the meeting of these two opposite movers? They must either return back, or go off together, or from each other, in some direction or other. I don't at present enquire which of these will happen; all that I assert is, that motion will not be lessened in this case, in either one or the other, or in both taken together; the change of direction only seems a necessary consequence of their impenetrability. The truth of this appears in the meeting of two quantities of elastic matter; the motion in this case is no way lessened by the opposite motions: it must then be something else than motion which lessens or destroys it; for nothing destroys itself, or its own force. We must carefully distinguish the effects which are necessary consequences of impenetrability, from those which are the consequences or the effects of the resisting agent; without this care, we shall often run ourselves into confusion, because of a faulty habit, which every one acquires, of confounding these very distinct properties in matter, impenetrability and resistance. The reason of this is, that all our ideas of motion are taken from resisting matter in motion, which is endowed with both these properties.

17. Suppose next, that two quantities of matter meet, the one of the moving agent, the other of the resisting, what will happen? If the resisting power be greater, or equal to the moving power, it will stop the action of

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the moving power, and both remain at rest, tho' the force, or endeavour, or power to move, still remain in the moving power; but if the moving power be greater or stronger than the resisting, then the moving power will only lose part of it's motion, and both will move together, with the remaining force of motion: this becomes a compound quantity, endowed with both motion and resistance. It is not my present business to prosecute this more particularly, but only to give general notions of these two different agents, and of their manner of acting.

18. Again, suppose that this united quantity of the moving and resisting agents, be by some means separated; I say, that the moving matter will, the moment after it is separated from the resisting matter, recover its first and original action of moving, or its whole motion: and the resisting matter will continue its motion in the same manner, or with the same velocity it did, while joined with the moving matter; and this by its power of resistance: for this power or force consists in persisting in whatever state it is at any time in, and in opposing all change of that state. As the degree of velocity, with which it moves, is the state in which every part of that quantity of resisting matter is in at the time; the force of resisting all change, or persisting in that state, in two different quantities so moving, will be as the quantities themselves; and in different quantities moving with different velocities,

velocities, as the velocities multiplied into the respective quantities of resistance. This force is called *Momentum*, by sir ISAAC NEWTON, and is by him rightly distinguished from motion: for it is plain, they arise from the actions of agents essentially different in their nature and manner of acting. It is likewise evident, that any quantity of resisting matter, moving thus by motion communicated to it, loses the whole, or some part of its motion, every time it meets with any other quantity of resisting matter, and never of itself recovers that motion again. The laws of this communicated motion (*Momentum*) being most common to our observation, are well described by philosophers: but the laws, by which the primary agents act, are little understood, though they be truly the cause of all the Phenomena in nature, and therefore deserve the trouble of further enquiry.

19. But besides these two powers, the one resisting, opposing or suppressing motion, or any alteration of its present state; the other a self-moving power, always changing or endeavouring to change its place, by moving in some one direction or other; there is a third kind of force or power observed, by which the parts of this thing receive any impression or action from any other agent, either the moving or resisting agent; and by a kind of reacting force communicates this action to all things round it, as by a kind of expansion of action, or such kind of action as seems to proceed

proceed from a center of every part, in strait lines to the surface: and this reaction is always observed to be equal to the force impressed. As we take our idea of this power from elastic bodies, whose parts, if by any force compressed nearer, endeavour to recede, and restore themselves with a force equal to that which compressed them; and thereby equally press every thing round them, which opposes the restoring of them to their first situation; it is usually called *elastic force*.

20. Now it is plain, that this elastic or expansive force cannot be the effect of the resisting agent: for the whole power of the resisting agent is exerted in preserving its present state, and opposing all change; but the very idea of this includes a perpetual endeavour of change by expansion. Again, the resisting power is exerted in opposing, lessening and rendering ineffectual all motion; but this power, by its reaction, preserves the motion impress'd upon it in its full force, and only alters the direction. Neither can it be the effect of the moving power: for the moving power exerts its force only in one direction; but this power exerts its force in all directions from every point. This then must be the force or power of an agent essentially different from both the resisting and moving agents: for the effect of this power cannot be produced by either of those agents singly, or by both jointly. The whole manner of action in this agent is singular and peculiar to itself.

itself. This power neither resists nor moves, and exerts no kind of action of itself, without the concurrence of some other power; so that in the absence of other powers, it must be conceived as in perfect inaction. Its power consists in this, that every part of it receives the impression or action of any other contiguous power; and by a kind of expansion, or elasticity, or reaction, every part reflects or expands that action which it received, in every direction, in an opposite direction as well as in the direct, and thereby communicates it to the adjacent parts. It must be conceived as existing alternately in two different states; the one of receiving, the other of reflecting, expanding, or reacting: it receives in one direction, and reflects in every direction: it has no manner of acting peculiar to itself, independently of the other powers; but receives any manner of action, either that of the resisting or moving power; and then, if this elastic matter be supposed to fill the space between any other species of matter, by a power peculiar to itself, it communicates the action of the one to the other at a distance, which otherwise could not be done: so that it is the general medium, by which all action is communicated to any distance from the acting power. This power of reaction, and reflecting any force impressed upon it, is the power peculiar to this species of matter; and it exerts this power in a manner similar to the manner of acting of
any

any other power, from which it receives its action.

21. The resisting power is negative to every other power, to the elastic power as well as the moving: for resistance must lessen every other action; and whatever lessens or weakens any action, is negative to that action. Therefore, in whatever degree the action of the resisting power is communicated to any part or particle of the elastic power, in the same degree the action of reacting or reflecting (which is the proper and peculiar action of elastic matter) is lessened: but the moving and elastic power being no way negative to each other, in no manner lessen or weaken each others action. For the same reason, the action of several quantities of the same power, acting in opposite directions, are in their directions negative to each other; because it is impossible they both can at the same time take their full effect: but the reaction of the elastic power, in the direction opposite to the direction of the action which it reflects, is not negative to that action, because performed at different times; as is evident from the idea of receiving and reflecting. Hence the action of every power must not be conceived as one continued act, but as a great many repeated acts or momentaneous vibrations; and that the reaction of the elastic power is in the interval of these acts or vibrations. This alternate action and reaction, or alternate systole and diastole, or undulating vibration is par-

particularly observed by Sir ISAAC NEWTON, in the passage of light thro' any medium.

22. This expansive or elastic force has been usually attributed to the shape of the parts which compose the elastic body. They are supposed to be spirial springs, like watch-springs: but why a spirial shape, or any shape, or any manner of arranging the parts of any thing, should give that thing any power which it had not before, is to me inconceivable. It is plain from common observation, that no shape can give an elastic force to lead; a spirial of lead is as little elastic as a strait line of lead.

23. As we cannot conceive this expansive or lastic power, otherwise than as consisting of parts, every one of which exerts its reactive force, as it were in lines from the centre of every part to its surface, and every part as acting upon all the surrounding parts, and acted upon by them; the agent exerting this force cannot be conceived otherwise than as extended and impenetrable; and therefore, that it is a species of matter.

24. It follows then, from the whole of what has been said, that these species of matter above described, are agents or acting principles; that each has a power or force peculiar to itself, differing from the others in its essence and manner of acting. Whether there be any more species of matter, is not easy to determine, tho' most of the ancients agree in this number. That these three are

essentially distinct, I can make no doubt. If there be any other distinct species of matter, it must likewise be an active principle: for we can have no idea of any thing but what arises from action, and there can be no property without some power or force. For this reason some of the ancient philosophers said, all nature is alive; that is, all nature is active. Try to describe matter without action, power, or force, the whole description must consist of negatives, that is, it must be the description of *no thing*; and then it very certainly follows, that no thing or no being exists no where. The word *matter*, defined to be a thing without action, without power, or force or property, is synonymous to the word *no-thing*; and then I think it requires no great penetration to demonstrate, that it exists no where, or is not: and yet this is the sum of some late learned and elaborate discourses.

25. The quantity of power, or the quantity of matter, are similar expressions; that is, a cubic inch, for example, of resisting, moving, or elastic matter, has half the quantity of resistance, motion or elasticity, that two cubic inches of the same power or species of matter have: but the manner of exerting that power, or degree of action, or of force, is as great in the cubic inch as in the two inches. Or more generally, every part of any species of matter has the power of acting in as great a degree as the whole has:
for

for where any power is essential, there can be nothing in the thing itself to obstruct the exertion of that power, and any external obstruction is not supposed. It is necessary therefore, to distinguish carefully between the quantity of power, and the degree of force, or of action, or of the manner of exerting that power: for velocity, for example, from the highest or quickest that can be conceived, to the slowest, may be divided into infinite degrees; and all these degrees are different manners of exerting the moving power. Since power is the essence or substance of the thing, nothing can communicate its power; for that would be to transubstantiate or to create: but every power can communicate a different degree of action or manner of acting, to another; and therefore it cannot properly be said, that any power communicates any quantity of power to another, but only some certain degree of force or manner of acting. And the only effects or alterations, which any power or agent can produce on another, is to communicate to this other, some degree of its action, or manner of acting.

26. The degree of action communicated, is always in the ratio of the quantity of the acting to the receiving power. Thus, if any quantity of moving power communicate any degree of motion to a cubic inch of the resisting power, or of the elastic, it will communicate but half that degree to two cubic inches: so that the degree communicated does

not consist in the absolute quantity of the acting power, but in the ratio it has to the receiving power.

27. This communicated action, or the effects of different powers, must be different according to the nature or different manner of acting. Thus, if any degree of motion be communicated, it cannot be augmented by the addition of a less degree, in the same direction; as the velocity of a ball moving at the rate of ten miles in an hour, cannot be augmented by the action of a ball moving at the rate of nine miles in the same time. Indeed, the first can receive no impulse or action from the latter; and therefore there can be no addition of different degrees of motion in the same direction: but it is otherwise in the resisting power.

28. Though the degree of resistance communicated, be always in the ratio of the resisting power to the receiving, as in the moving, the effects arising from it are different from what they are in the moving: because it exerts its action not in one single direction, as the moving power, but in every direction. For example, if any quantity of resisting matter communicate to a quantity of elastic matter, a degree of resistance, as 10, and another quantity of resisting matter communicate to another quantity of elastic matter, a degree of resistance as 5; whenever these two quantities of elastic matter are contiguous, their several degrees of actions must be united
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in the reaction, which is exerted or expanded in all directions; and therefore, in the reaction, the degree of action between these two, will be equal to 15 degrees of resistance: For since the action of resistance is negative to the other action, and thereby lessens it; it is evident, that, though the moving power be lessened in any degree by a strong action, it may be still further lessened by the application of a weaker action.

29. However, there still remains a distinction to be observed between the effects of the power itself, and of the action communicated to another thing: for example, any quantity of elastic matter, having any degree of resistance, or of motion, communicated to it, cannot communicate a greater degree than what it has received; if it communicate the whole degree to another inch of elastic matter, it cannot communicate a greater degree to half an inch. It is otherwise as to the power itself: for, if it communicate a degree, as 10, to any quantity, it will communicate a degree, as 20, to half that quantity. And it is likewise to be observed, that though the degree of communicated action cannot, by being communicated to a less quantity, be increased; yet it may be lessened by being communicated to a greater.

30. If upon further inquiry into the nature and manner of acting of these several agents, some of the most general phenomena in nature become plain, and easy to our conception,

tion, and which have hitherto puzzled the greatest philosophers; it will be a strong additional proof of what has been advanced. My next attempt shall be, to shew this in some instances; and before I proceed, I shall only observe, that perhaps the chymists aim at the same thing I do, in the three principles which they establish, viz. *Salt*, *Sulphur*, and *Mercury*: By *Salt*, they may intend the resisting matter or power; by the action of which chiefly the parts of matter (as will be afterwards shewn) attract each other, or are kept in union: By *Sulphur*, the moving matter, by which, motion, or that kind of action, which is most evident to our senses, is produced; and by *Mercury*, the elastic matter, by which (like a messenger) the action of one is carried thro' any distance to another, and like *Mercury* or *Proteus*, takes or imitates the action of either of the others: but the inquiring into the opinions of philosophers on this subject, is beside my present purpose:

POSTSCRIPT.

I AM very sensible how difficult it is to convey any new conceptions of things, or which are contrary to notions confirmed by long habits. This was the case of sir ISAAC NEWTON'S *Theory of Light and Colours*. It was violently opposed by some of the greatest philosophers at that time; and every one per-
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ceives, on his first reading of that book, with what reluctancy he yields to the evidence of truth, which forces his assent. What can seem more absurd to common observers, than to be told, that there is no colour in any body we see; that all colours are only in the light, and that white is made up of a mixture of all colours? Tell this to any man not conversant in that theory, and he'll immediately think, that you are a fool, or design to play the fool; and yet there is no man, who understands sir ISAAC's book, that can doubt of the truth of these things. After we have been accustomed to the reasonings and ideas communicated by sir ISAAC NEWTON, we find no difficulty in these conceptions, which seemed at first the most difficult to conceive; and I presume, that after a close attention and repeated reflexions, the reader will find the same easiness with respect to the doctrine here delivered.

I find most people startled, when I tell them, that the resistance of a body at rest, or without motion, is performed by some action in the resisting body. When a body at rest, or without motion, resists, does it do any thing?— or nothing? If it do nothing, it does not resist; if it do any thing, it must act; and if it act, there must be action without motion. It is surprizing, to find it so difficult for a thinking being, to conceive action without motion. When a man thinks he does something, then thinking is acting, or is a kind of action; but this action cannot be
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conceived as consisting either in motion, or in resisting, or in reflecting motion : it is a kind of action different from every one of these.

But I find it is expected, that I should explain the *Modus* or manner of acting in resisting matter ; otherwise it is concluded, that the whole theory is defective and uncertain. Tho' I cannot explain the *modus*, or manner of acting, when I think ; I hope none will deny, that I do or can think : but I will say more ; we cannot explain the *modus* or manner of acting of any simple power, no not of the moving power. When a quantity of moving matter puts another quantity of matter into motion, what conception have we of the *modus*, or of the manner of acting ? If it be said, to be by pushing or pressing the body which it moves ; I must ask again, what idea have you of *pushing* or *pressing* ? Have you any other idea, but that the moving body communicates motion to the body which it pushes or presses ? As to my part, I can form no other conception of pushing or pressing ; and if any other can, I shall be exceedingly pleas'd to see its *modus*, or manner of acting explained : 'till this be done, I shall presume to say, that we may have as clear and distinct a conception of the *modus*, or manner of acting in resisting matter, as of the action of moving matter ; that is, that resisting matter communicates its action to the matter on which it acts. I must likewise add, that we have no idea of any thing but of action ; and that *all ideas arise from*

from the communication of some kind of action to the thinking thing or being: simple ideas arise from the actions of simple powers, and complex ideas from the complicated actions of several simple powers: no simple idea can be explained; as I think is confessed by all; and the explication of complex ideas, is the shewing of what simple ideas they are compounded. Let any man shew any idea, which does not evidently arise from some action or other, if he can.

In the last place, I must observe, that, tho' I call that matter or power, *elastic matter*, which reflects any action, or conveys any action from the acting matter or agent, to any distance from it (being a term used by sir ISAAC NEWTON, and other philosophers); yet the action of this elastic matter must not be conceived as in any manner similar to that of elastic bodies, such as a ball of ivory; but as a kind of action singular and peculiar to itself, and which cannot be explained by any similitude to the action of any other thing, no more than the actions of resisting or thinking can be explained by any similitude to the action of moving. Therefore, if one should imagine, the elastic matter to consist of innumerable small globules, (as of ivory) whose parts being pressed together, rebound with the same force with which they are compressed; he would have no conception of the elastic matter which I mean. The actions of

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all first principles, and the ideas of them, must be all simple; nothing of shape, or of parts, or of number, or of any thing like composition, can enter into these simple actions, or into the ideas of them: for otherwise they cannot be simple. In any conception of globules, they must be conceived as consisting of parts; which being pressed nearer to each other, endeavour to separate again: and as this cannot be conceived otherwise than as in motion, such elastic power can never reflect or continue any other action but that of motion. These parts which are thus supposed to contract and dilate, have either the same elastic power, or not: if they have not, then an aggregate has a power which no part of it has: if they have the same power, they must be again compounded of others, till we come at last, in conception at least, to such as are not compounded; these, then must have this elastic power without any contraction or dilatation of parts. If it be said, that this division into parts goes on *in infinitum*; and therefore can never be reduced to single parts: in this case we must suppose that the aggregate has power or action which none of its parts have; and that the power of reflecting or reacting consists only in number, and not in the thing itself. It is true, that in machines, and such like aggregates, there is a kind of compound action, which none of the parts have separately; and by this the machine

chine or aggregate becomes a kind of *unity*, (or τὸ ἓν, as the *Greeks* express it); for its essence is destroyed by division, and it no longer remains the same thing: but every one easily perceives, that no machine can be a simple being, nor its action simple, but is the complication of the actions of several simple actions; and therefore the nature of all machines, and the manner of their acting can be explained; but the manner of acting of simple beings, as before observed, cannot be explained.

CH A P. II.

Of Æther and Gravitation.

31. **S**IR ISAAC NEWTON, with wonderful sagacity, has discovered, that *Gravitation* is an effect of some cause or agent, which operates in every part of the universe of which we have any knowledge; and he has described its manner of acting, so far as can be concluded from the effects: but what that cause is, whether it acts by attraction or pulsion, he has no where determined. And tho' in several parts of his writings (in the last editions) he has more expressly declared his opinion, that the agent which makes all

bodies gravitate towards each other, acts by pulsion; yet the manner he has taken to explain this pulsion, has not given that general satisfaction which the other parts of his writings have; and he having at first explained himself, as done by attraction, his followers have frequently been puzzled, and foreigners have received a prejudice to the whole of that doctrine. Suppose that gravitation be by attraction, how can two bodies be supposed mutually to draw each other, without something like strings passing between them? but the free motion of any other body between these two, shews, that there can be nothing of that kind between them. Again, the force of gravitation towards any body being at every distance reciprocally, as the squares of the distances, seems to shew, that gravitation is the effect of some emanation from the attracting body: for the force of the emanation of any virtue, proceeding from any body, as a center in strait lines, is at every distance reciprocally, as the squares of the distances; which is demonstrated by dr. Gregory, in the 48th proposition of the first book, and 57th proposition of the third book of his *Astronomy*. But this no way lessens the difficulty: for how can we conceive, that an emanation or motion from any body, can make another move towards it. These difficulties, and some others, have prevented the general reception of a doctrine, which evidently agrees with all phenomena. If I
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can shew then, how gravitation is performed, so as one may be able to form a clear conception of the same, consistently with all manner of acting, of which we have any certain knowledge, and founded on the principles before explained; I hope to do something that will be acceptable to the curious.

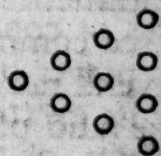
32. Sir ISAAC supposes, that there is a fine subtile fluid, or *medium*, expanded thro' the universe, which he calls *Æther*. This occupies all the space not filled with other matter, and permeates all the interstices or passages, which are in or between bodies. He brings several proofs of the existence of such a medium, in the 18th and 21st queries, at the end of his *opticks*, and in several other places of that book. Every philosopher almost has supposed the existence of some such thing; all agreeing, that it is impossible to account for the general and constant phenomena, without the existence of such a medium. We have no way of discovering the existence of any physical agent, thing or being, but by the mediate or immediate impression it makes on our senses. We only discover the agent by the effects, and the manner of its acting, by a continued observation of effects. If then from a general observation of many perpetual phenomena, and of the particularities in them, they appear to be the effects or action of an *elastic agent*, (19, 20,) and necessarily follow, if such an elastic agent exist; we thereby

by have the same proof of the existence of such an agent, that we have of the existence of resisting matter, or of moving matter: for neither our senses nor our ideas reach to the things or substances themselves. We have no idea or conception of any thing other than of its power or force, or of the action or manner of its exerting that power or force. By the effects of the resisting or moving matter, either mediately or immediately on our senses, we conclude that such powers exist; and no otherwise have we any proof of their existence: so that I presume to give the same proof of the existence of *æther*, (or of an elastic medium) that can be given of the existence of any thing whatsoever, that does not immediately strike our senses.

33. Suppose then a line of elastic matter, *a, b, c, d, e, f, g*, consisting of any number of particles or parts; then if any impression be made, or action communicated on *a*, it will communicate the whole of the impression or action, and the whole force it received, to *b*, and *b* in like manner will communicate the whole force to *c*, and *c* to *d*, and so on, thro' the whole length of the line, however long it be: and with whatever force *a* presses *b*, with the same force *b* in its reaction will press *a*, and so *c* will press *b*, &c. the reaction will every where be equal. If you say, that *a* communicates less to *b*, than it received, and *b* less to *c*; the communicated force continually decreasing,

sing, by reason of the resistance of the several parts: I say, that you have not sufficient attention to the caution given before (16, 20): for elastic matter has no power of resisting in itself.

34. Suppose again, any triangular surface, filled with particles of elastic matter, or of æther, in such manner, that the number of particles in each rank or line continually increase equally: then whatever degree of action be communicated, by any power whatsoever, to the single particle at the top, it will communicate one half of that degree to each of the two particles in the next rank, and one third of that force or degree of action to each particle in the third rank, and one fourth to each particle in the fourth rank, &c. For, since the single particle communicates the whole force or degree of action which it received, to two particles, it cannot communicate more than one half to each, otherwise it must give what it has not received; nor does it communicate less, because there is no resistance to lessen it. Then the force or degree of action, in this case communicated to each particle in each rank, will be as the distance of the rank applied to the force or degree of action of the first particle; that is, as 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c. Now it is plain, that the difference between 1 and $\frac{1}{2}$, is greater than $\frac{1}{2}$ and $\frac{1}{3}$, and the difference between $\frac{1}{2}$ and $\frac{1}{3}$, is



is greater than between $\frac{1}{3}$ and $\frac{1}{4}$, and so on; likewise, $1 : \frac{1}{2} :: 2 : 1$, and $\frac{1}{2} : \frac{1}{3} :: 3 : 2$, and $\frac{1}{3} : \frac{1}{4} :: 4 : 3$. Therefore, these continually decrease reciprocally, to an increasing arithmetical progression. Then the degree of force communicated to each particle of the several ranks, will, in the several ranks be in the ratio of numbers decreasing reciprocally to arithmetical increasing proportionals. Then by the reaction of the æther, in this triangular surface of it, each particle of the outermost or farthest line or rank, from the summit or point, will communicate the degree of force or of action which it received, to the particles in the next line or rank within it, to which the direction of its reaction can go. This second rank, having its communicated degree of action thus augmented, will, by its reaction, communicate its degree of action to the particles of the line or next rank within it, in like manner; and thereby this third line or rank of æther, will have its degree of action augmented in the ratio of the first and second lines or ranks; and in like manner the fourth will be augmented by the addition of the first or outermost, second and third; and the fifth by that of the first, second, third and fourth. Thus the force or degree of action of the several ranks or lines in this triangular surface of æther, being thus changed by a continued addition of their ratio's, in an order reciprocal or contrary to the natural or direct order of increasing ratio's,

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the ratio of force communicated to the single particle at the summit, will become 15; the ratio or degree of force communicated to each of the two particles in the next will be 10; to each of the three next 6; to each of the four next 3; and that of each of the five outermost will be 1: and the differences of degrees of action communicated by the reaction to the particles in each line, from the summit or single particle, will be, 5, 4, 3, 2, 1, or decreasing arithmetical proportionals.

35. In order to understand the nature of reciprocal ratio's, it is to be observed, that as the direct are the ratio's of quantities greater than unity; so the reciprocal are the ratio's of quantities less than unity; and that unity is the common measure, to which both are referred. Therefore the ratio's of equidistant terms from unity of similar series, the one increasing, and the other decreasing, are always the same. So likewise, if any addition, subtraction, multiplication, or division, of any number of terms of the direct or increasing series be made; and a like addition, subtraction, multiplication or division of the correspondent equidistant terms from unity, of the decreasing or reciprocal ratio; the ratio arising from such addition, subtraction, multiplication or division, will in both series be the same. These two series then are properly thus expressed, (&c. $\frac{4}{1}, \frac{3}{1}, \frac{2}{1}, 1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4},$ &c.) that is, $2 : 1 :: 1 : \frac{1}{2}$, $3 : 1 :: 1 : \frac{1}{3}$, and $4 : 1 :: 1 : \frac{1}{4}$, &c. Then $2+3 : 1 :: 1$
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: $\frac{1}{2} + \frac{1}{3}$, or $5 : 1 :: 1 : \frac{1}{5}$, and the sum of all, $10 : 1 :: 1 : \frac{1}{10}$. For the denominators in the reciprocal, are indexes of the same ratio's, that the integers or numerators are in the direct. Therefore the reciprocal ratio's may be as well expressed by negative numbers, thus, -2, -3, -4, &c. as by the fractions; they both equally shewing the ratio to unity. Therefore, whatever be the product of two or more series of increasing ratio's from unity, however combined, the same product will arise from the similar combination of similarly decreasing series from unity; and the one may be substituted in the place of the other. But to avoid mistakes, it must be carefully observed, that what is here affirmed, is not of the quantities themselves, but of their ratio's only; and this distinction between the ratio's of quantities and the quantities themselves, is constantly to be kept in mind; for otherwise many difficulties may arise, or objections be made to what follows, only from not observing this distinction: for generally, I treat of only the ratio's of quantities, and not of the quantities themselves.

36. But in the case of the triangular surface of æther here put, the æther is supposed to be bounded; which case really never happens, because the æther is expanded through the universe: therefore, though I put it for the more easy conception of the ratio of action communicated, this supposition is in several respects defective in giving a true conception

ception of the reaction of the æther: and, as the action of resisting matter is negative to all other power; the general supposition of any action cannot so clearly shew that of the resisting power. Let us suppose then, an unbounded surface of æther; then if any point be taken in this surface, and the action of the resisting power be communicated from this point in all directions; these directions become so many radii from this point. From the same point divide the surface into any number of circles, so that their radii be increasing arithmetical proportionals; the circumferences of these circles must likewise be increasing arithmetical proportionals. Now, by the same reasoning used in the case of the triangular surface of æther, the ratio of action communicated to the particles of æther in each circumference, must be in the reciprocal ratio of the radii, or of the circumferences themselves; and the reaction in the same direction or radius, must be reciprocal to increasing numbers, whose differences are arithmetical proportionals. But as this ratio of increase of the reaction is fundamental in the idea of the manner of acting of the æther; it may be necessary to explain this more fully, in order to give an adequate conception of it. The reaction or reflection of action of every particle of æther (20) is equal in every direction; then if any particle *b*, in any of these circumferences be taken, and two other contiguous particles, *a*

and c , in the same circumference, one on each side; the action communicated to these three particles being in each equal, the reaction of b , in the direction of the circumference, must be made null (21) towards a , by the equal and opposite reaction of a ; and its reaction towards c , be made null by the reaction of c : therefore the particles of æther can have no reaction in the directions of these circumferences. Again, take any number of contiguous particles, a, b, c, d , &c. all in the same radius or direction to the center, but each in different circumferences; since the action of the resisting power communicated to their several particles, is reciprocal to their distance from the center, or is less in the ratio of their distance; and, as the resisting power is negative (21) to every other power; the power of reacting or reflecting any action, must be less in the particles nearer to the center, than in those further from it; and consequently the particles further from the center, must have a stronger reaction, or force of reflecting, than those that are nearer: then there can be no reaction in the direction from the center; for the stronger and contrary action must annul the weaker in contrary directions (21): therefore all reaction in the direction of every radius must be towards the center; and being in all instantaneous (21), the action of the farthest distant particles must strengthen or increase the action of the nearer to the center.

ter. For the action must in one instant be communicated to the outmost extent, and the reaction made through the parts in the next instant.

37. Suppose in the third place, a cone of such elastic particles or of æther, and that this cone is divided transversely to its axis, into any number of parallel segments or circular surfaces: in this case the content of each segment or circular surface is as the squares of their distances from the summit of the cone. Then any force or degree of action communicated from the summit, or single particle at the top, to each particle in each circular surface, will be as the force impressed upon the first particle applied to the squares of the distances, or reciprocally as the squares of the distances. And the force communicated to each particle in one circle, and to each particle in the next contiguous circle, is reciprocally as the squares of their distances from the top of the cone: that is, as $1, \frac{1}{4}, \frac{1}{9}, \frac{1}{16}, \frac{1}{25}, \&c.$ Therefore by a similar reasoning to that in the preceding paragraphs, the force or degree of reaction of the æther in the several surfaces, will be reciprocal to a series of increasing numbers, whose differences increase as the squares of arithmetical proportionals, or reciprocal to these numbers $1, 5, 14, 30, 55, \&c.$

38. In the fourth place, suppose a particle of this elastic matter placed in the center of a sphere of the same matter, and that this
sphere

sphere be divided into any number of concentric spherical surfaces. Now, since the contents of these spherical surfaces are as the squares of their distances from the center, any force communicated from the center to every particle in each respective spherical surface, is as the force at the center applied to the squares of their distances, or reciprocally as the squares of increasing arithmetical proportionals; and the reaction will be reciprocal to an increasing series, whose differences increase as the squares of arithmetical proportionals: for the reasoning in this and the preceding case is entirely the same.

39. Now, since elastic matter communicates any impression or force made upon it, in the manner above described; let there be any quantity of resisting matter placed any where in the æther, which is supposed to extend all over the universe: this resisting matter is an agent continually and necessarily acting and exerting force, (8) and must therefore communicate its action or manner of acting, to the parts of the æther contiguous to it, and they to others next to them. (20) Therefore calling any quantity of resisting matter a *body*; and supposing a spherical body placed in the æther, and the æther round it divided into any number of spherical surfaces, concentric with the sphere of resisting matter: then the force impressed by the resisting agent, which is here supposed a spherical body, will be communicated to the particles in each spherical surface
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of æther, in a ratio reciprocal to the squares of their distances. (38) And therefore by the reaction as above described, the elastic force of every particle of æther surrounding the resisting body in its action of reflecting the action of any motion, will be lessened in a ratio reciprocal to increasing numbers, whose differences are increasing squares of arithmetical proportionals: for the action or force of resisting matter, is to obstruct or lessen, or is negative to the action of all other power or force.

40. Then if any moving thing or power or agent, be placed within this sphere of æther, surrounding the resisting body; it will by the reaction in the æther of its own action be pressed on all sides by the elastic particles of æther, whose force of reaction increases reciprocally, as in the preceding paragraph. Therefore, that thing will be more pressed on the side which is from that body, than on the side towards it, and must therefore approach towards the body, every where with a force equal to the difference of force of the elastic particles of æther, on the opposite sides of the thing. But these differences are every where (39) reciprocally as the squares of the distances: therefore every body will seem to attract another in motion, with a force every where reciprocal to the squares of the distances from that body; though more properly speaking, this thing is repelled towards the body, by the elastic force of the æther before described;

described ; or if the æther be put in motion from any cause (as it must constantly be by the continued transmission of light from the sun, planets and stars) the reaction of this motion will be stronger on one side of a body at rest, within the sphere to which the action of the resisting body is communicated, than on the other side ; and thereby this body will be repelled towards the other body, within whose sphere of æther the action of the resisting body is communicated.

41. Here again, before I proceed further, I must take notice of an objection which probably will arise from the commonly received idea of resistance, and which I observe is apt to return, notwithstanding what has been already wrote to prevent it. One is apt to think, that resistance is one single act, which only happens when two bodies in motion, and in opposite directions, meet each other ; or when a small body in motion meets a greater one at rest, where after the first shock they both remain at rest, and all action is supposed to cease. Since then (it may be said, resistance is only a single act, whatever impression be made by it on the æther, it can only be momentary ; and all action between the resisting body and the æther must afterwards cease. I have already endeavoured to explain this (16, 17, 24, 25,) and I shall only now repeat, that the mistake proceeds from thinking that there is no action, but what consists in motion ; but as resistance is a power essential to one species
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of matter (24, 25,) this species can never cease in exerting this power, or must be continually in action: and as this action of resistance is contrary to, or negative of motion, nothing of motion can enter the proper conception of it. Suppose that any quantity of resisting matter meet a quantity of moving matter, and by its action of resisting, stop the motion or action of the moving matter; and that immediately after this momentary stop, the resisting matter ceases to act or to resist, must not then the moving matter recover its action or motion, since there is nothing to resist or hinder it? Power and force, and consequently action, is essential to both these species of matter; and in this case, while both remain at rest; they both exert their force or power: but their actions being contrary and equal, and negative of each other, the degree of action in each becomes $=0$. But as there is nothing in the elastic power contrary to, or negative of either the resisting or moving powers, it equally receives the action of both; and every part of elastic matter reflects the actions of both, with the same degree of force with which they were impressed.

42. Now, supposing any spherical quantity of resisting matter to be placed in the æther, the action of the resisting matter will be communicated in the manner described (38). If then any body without motion, be placed within the sphere of æther, to which the

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action

action of the resisting matter is communicated; this body can have no motion, either towards the resisting matter, or from it, or in any direction: for since the action of resisting matter is negative of motion, and the æther of itself has neither the action of resisting nor of moving, and motion is not supposed to be communicated to the æther otherwise; this body thus placed in the æther, can acquire no motion, but must remain in any place in that sphere where it shall happen to be placed. But if this body move, or have the action of moving, or if motion be communicated to this sphere of æther from any other cause; then the reflexion of the action of motion, from the several particles of æther, will be different: so that the reflexion will be always less in the particles nearer to the resisting matter; because the reflexion of the action of the resisting matter, at the same time communicated to these particles of æther, is negative to the action of motion, and greater the nearer these particles are to the resisting matter. Then any thing or body in this case, placed within this sphere of æther, will have the action of motion more strongly impressed or reflected upon it, by the æther on the side furthest distant from the resisting matter, than on the side nearest to it: and the difference of the force of reflexion on these two opposite sides, being every where within that sphere reciprocally, as the squares of the distance from the resisting matter; that
 body

body will be repelled towards the resisting matter, by a force or degree of velocity, every where reciprocal to the squares of the distance from the resisting matter.

43. It follows then, that no species of matter has in itself a power of attracting any other, or of gravitating towards any other; but that this apparent attraction or gravitation, is truly and really performed by pulsion, or more properly is the effect of the joint actions of the moving, resisting and elastic powers: however, as the *Copernican* astronomers speak of the motion of the sun and stars, tho' they know that they are ever at rest; so I think it may be allowed me, to treat of attraction and gravitation, and to consider this apparent action as if it were real; tho' I be perswaded, that the notion of attraction and gravitation arises from a false conception of things; and therefore I shall next shew, how far this theory agrees with the general phænomena of attraction and gravitation.

44. Every spherical solid may be considered as composed of spherical surfaces, and the ratio of every outer surface to the next contiguous surface within, increases as arithmetical proportionals; for the ratio's between any quantities increase as the differences of these ratio's of quantities, and the differences of the ratio's of these surfaces are arithmetical proportionals: therefore the ratio's of the degrees of force, which every spherical surface of the body from the center outwards, shall

communicate to the surface of æther next within it, will increase as arithmetical proportionals, or as the numbers 1, 2, 3, 4, 5, &c. Then the force of resistance communicated to the several surfaces, by reaction of the æther, will become as 5, $5+4=9$, $5+4+3=12$, &c. or as these numbers, 5, 9, 12, 15, 15. Therefore the force of attraction within any body, will be as the differences of these numbers, or every where as the distance from the center of a spherical body. Here it is to be observed, that since the degree of action communicated to the æther within a spherical body, increases directly from the center, and is not lessened reciprocally, as without the body; the degree of action from the reflexion of the æther, is increased by a direct addition of the ratio's, not by a reciprocal addition, as without the body.

45. This may be otherwise demonstrated thus: of all the directions or lines passing thro' any particle of a sphere, that is the longest within the sphere which passes through the center; therefore that line in a spherical quantity of resisting matter, has more resisting matter in it, than any other line of the same sphere not passing through the center: consequently the elasticity of all the particles of æther in that line must be more lessened than of those in any other line; and therefore the reaction of every particle of æther must be in the direction or line passing thro' the center. Likewise the length of every line within the sphere,

sphere, passing thro' any particle of the sphere and the center, is longer on that side of the particle on which the center is, than on the opposite side towards the surface, and consequently the elasticity or reaction is most lessened on that side; the reaction of every particle must be towards the center of the sphere. Again, since every line of a sphere passing thro' the center, is equally divided at the center, the opposite directions of reaction in every line must be equal at the center; and therefore the reaction of the æther at the center must be $= 0$. And since the differences of the lengths of the lines passing thro' every particle and the center, on one side, and the opposite side of that particle, increase as the distance of the particle from the center, the differences of the ratio of force or degree of reaction in every particle, must be as it's distance from the center. The same kind of reasoning may easily be applied to the sphere of æther surrounding a body of resisting matter, and to which the action of the resisting body is communicated.

46. Then, if any spherical body be placed any where in an unlimited quantity of æther, and the æther be supposed to be divided, as well within the body as without it, into any number of spherical surfaces, concentric with the spherical body; the elastic force of the æther will be at least at the center, and will continually increase from the center, but in different ratio's within the body and without it.

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Within the body it increases as the squares of the distance from the center, so that the differences between each two spherical surfaces within the body, are directly as their distance from the center: but without the sphere the elastic force increases reciprocally, as numbers whose differences are squares of the distance of the surface from the spherical body; and the difference of force of elasticity, between each two elastic particles is reciprocally, as the squares of the distance from the spherical body.

47. Gravitation towards any spherical body, is directed in lines tending to the center of that body, and may be represented by two different decreasing progressions, the greatest term of both which is common to both, and at the surface of the spherical body; one of which progressions decreases towards the center reciprocally, as the distance from the surface, and the other decreases from the surface outwards reciprocally, as the squares of the distance from the surface. Thus, if C be put for the center of any sphere, S its surface, and A the limit of or extremity, to which the action of the sphere is communicated in

$$C \xrightarrow{\quad S \quad} A$$

$$cad \quad ebf$$

any line passing through the center: then if CS and SA be each equally divided at a and b , the ratio or degree of gravitation will be twice as great from S to a as from a to C , and four times as great from b to S as from A to b , or in the reciprocal ratio $aC \frac{1}{2}$ of aS and

and $A b \frac{1}{4}$ of $S b$. Again, if CS and SA be each divided into three parts, Ca, cd, dS and Se, ef, fA ; then the force of gravitation will be three times greater from S to d than from C to c , and twice greater from d to c , than from c to C ; but the gravitation from e to S , will be nine times greater than from A to f , and four times greater from f to e , than from A to f . Therefore,

48. Into whatever number of parts the distance to which the action of resisting matter extends, or the force of attraction: the ratio or force of gravitation in each of these parts may be found: but if the distance be divided infinitely, the degree of gravitation will become an infinite series, increasing reciprocally to the squares of the distances from the resisting body.

49. Then an infinite series of proportionals increasing reciprocally as the distances, or directly as the distances, or reciprocally as the squares of the distances, may be in any finite distance; and if the ratio's or differences between any finite parts of such infinite series be finite, the distance to which all the series extends must be finite. Therefore, if the ratio of the attraction of the sun, or of the planets, can be determined in any finite distances, the distance to which the attraction of the sun and planets extends, may be finite and may be determined: therefore it is not universally true, that all bodies mutually attract each other.

50. If

50. If the velocity (or the times being reciprocal to the velocities) with which any body passes by gravitation; thro' three equal and continued distances, be given, the distance to the limit of attraction, or to the extent of action of the resisting body (which is supposed to attract) on the æther, may be found thus: suppose the velocities be 36, 45, 55; then $55-45=10$, and $45-36=9$, since 10 and 9 differ only by unity; it shews, that the distance where the velocity was 55, was the tenth of such distances from the limit of attraction; but if the three velocities be 64, 81, 100, the differences will be 19 and 17, and the difference of these numbers is 2, then $\frac{19+1}{2}=10$, and $\frac{17+1}{2}=9$; which shews, that these velocities were acquired in the 9th and 10th of such equal distances from the limit of attraction: the same result will be if the velocities were 15, 32, 51; for the velocities are as the squares of the distances, and the differences of these squares are as the distances.

51. Here it may be observed, that since lines are composed of points, and surfaces of lines, so solids of surfaces; a triangular surface may be conceived as composed of an infinite number of lines, increasing in an arithmetical progression: so likewise cones may be conceived as compounded of an infinite number of surfaces continually increasing, so that the differences between them are increasing arithmetical proportionals; therefore instead

stead of a series produced by the continual addition of arithmetical proportionals, or by the continual addition of the squares of arithmetical proportionals, we shall hereafter say, a series of the squares of arithmetical proportionals, or a series of their cubes. It is true, that these infinite numbers are not perfect squares and cubes of arithmetical proportionals, but as the number of terms increase, they come nearer and nearer to the truth, and in infinite series they are perfect squares and cubes: for if any triangular surface, for example, be supposed to be divided into any small number of lines, these lines must have some breadth; then the opposite sides of the triangle, in which the lines terminate, will not be strait lines, but like so many steps of stairs; but the more of these steps, they must be the smaller, and the differences of the lines less; and therefore if the number of lines be infinite, the steps must vanish, and the sides become strait lines. Now, if the parts of the æther be infinitely small (as we have reason to think, and may perhaps afterwards be proved) there must be an infinite number of surfaces of æther in every finite space; and therefore we may properly say, that these series composed of increasing squares are truly solids or cubes: for all similar solids are as the cubes of their homologous sides? And if from observation it shall appear, that the series of elasticity of the æther (as above described) at several distances, is

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perfectly as the cubes of these distances, the particles of æther must be infinitely small. See *Wallis's Arithmetica Infinitorum*.

52. Suppose any cubical quantity of resisting matter be divided into any number of square surfaces, all equal to the side of the cube; then the action of each of these surfaces communicated to the surface of æther, contiguous to the side or surface of the cubical body, will be as follows: calling each square surface, into which it is divided, x , that of the outermost will be $\frac{x}{1}$, of the next $\frac{x}{4}$ of the third $\frac{x}{9}$ of the fourth $\frac{x}{16}$, &c. and the action communicated to the surface of æther contiguous to the cubical body, by the cubical body, will be equal to the sum of the actions of all the square surfaces, which compose it. But, by 21 *Prop.* of *dr. Wallis's Arithmetica Infinitorum*, the sum of an infinite series of the squares of arithmetical decreasing proportionals is equal to one third of the sum of as many surfaces, all equal to the greatest; that is, in this case of so many all equal to the square surface of the cubical body: consequently the force of attraction of every quantity of resisting matter, is equal to one third of the quantity of matter. (35, 38, 39, 47, 48, 49.) Therefore,

53. In several quantities of matter increasing, as the cubes of arithmetical proportionals, the differences between the quantity of matter, and force of attraction increase continually, as the cubes of arithmetical proportionals:

portionals: for supposing three cones or pyramids, A , B , C , of equal height, but the bases to be of A as 1, of B as 2, and of C as 3; then A will represent the force of attraction, C the quantity of matter, and B the difference between the force of attraction and quantity of matter. Now at the points in their summits, all these three cones or pyramids are equal, or their differences are $= 0$; and if the axis's of these cones or pyramids be equally divided from the points in their summits, and they be likewise infinitely continued; each will be from their summits cubes of arithmetical proportionals increasing infinitely: therefore, *in several quantities of matter increasing, &c.* Sir ISAAC NEWTON, and several after him, have observed, that the force of attraction in little bodies, at the point of contact, is prodigiously greater, in proportion to their bulk, than that of great bodies at their surfaces; but I know not that any have assigned the reason of this, or have given a rule for discovering these differences.

54. If then three homogeneous bodies, increasing as the cubes of arithmetical proportionals, be taken, and the force of attraction of each of these at their surfaces, or at any equal distance from their surface, be discovered; the force of attraction of all other bodies homogeneous to them, may be discovered by a similar method to that in Par. 50. Experiments perhaps may be contrived on these principles, to discover whether bodies

be homogeneous or not, and whether there be different species of resisting matter, (12) differing in their force of attraction, as the rays of light in their refrangibility.

55. The distance, extent or radius of the sphere of æther, to which the action of any body or quantity of resisting matter is communicated, is much longer in little bodies, in proportion to their bulk, than in great bodies: for the extent or number of terms of any series decreasing, as the cubes or as the squares of decreasing arithmetical proportionals, is as the cube root or square root of the highest or first term of each series. And this holds true in infinite series as well as finite; for example, suppose two quantities, one as 100, the other as 300; their force of attraction at the surface is as $33\frac{1}{3}$ and 100, and the extent of their attraction nearly, as 6 and 10. Again, if the quantities of resisting matter be as 300 and 3000, their force of attraction will be as 100 and 1000, and the extent of their attraction as 10 and not quite 32.

56. Suppose any body or quantity of resisting matter, or of moving matter, or of both resisting and moving matter, mixed in one body, placed within the sphere of æther, to which the action of resistance of any other body is communicated, and that motion by any means be communicated to the same sphere (42); then the first body will appear to be attracted, or to gravitate towards the quantity of resisting matter: and tho' these apparent actions of the attracting and gravitating

tating bodies, really arise from the same cause; yet the force of gravitation in different gravitating bodies, may be very different from the force of attraction in the same bodies. For gravitation is caused by the action of the æther on every particle or part of the gravitating body, on the parts of the moving matter contained in that body as well as on the resisting; and tho' there be different species of resisting matter, the action of the æther may be equal on all of them, and they may all equally gravitate; but the force of attraction in different bodies, is only as the resisting matter in these bodies; neither is it as the quantities themselves: therefore, by observing the differences of attraction and gravitation in the same bodies, and by contriving proper experiments for that purpose, or perhaps by observing the phenomena of the great heavenly bodies; the quantities of resisting matter and moving matter in these several bodies, or in the great heavenly bodies, may be discovered, and whether there be different species of resisting matter. Here, I suppose, that the æther acts upon every part or particle of bodies, and freely permeates between and round all the parts of every body: it is beside my present purpose to prove this, but pethaps it may be afterwards done, when it can be shewn by what power, force or action, the parts of bodies cohere.

57. I shall next proceed to shew, the joint action of two distinct bodies or quantities

ties of resisting matter, on the æther round them, or on the æther between them and on their outer sides. But, to make this the more clear to readers, who have not a distinct notion of reciprocal ratio's, I shall first observe, that if there be

any force or action of any $A \xrightarrow{3 \ 2 \ 3} B$
power decreasing in the

line AB reciprocally, as the distance from A ; then if that line be divided equally in 2, the force in $2 B$ will be $\frac{1}{2}$ of that in $A 2$; but if the distance be taken from B , and $B 2$ be 1 or x , $2 A$ will be 2 or $2 x$. If the line be divided into 3 parts, as $A 3$, $3 3$, $3 B$; then if the distance be taken from A , and the force in $A 3$ be 1, that of $3 3$ will be $\frac{1}{2}$, and that of $3 B$ will be $\frac{1}{3}$, that is, reciprocal to the distance from A : but if the distance be computed from B , and the force in $3 B$ be 1, that of $3 3$ will be 2, and of $3 A$ will be 3, directly as the distance from B ; and so in like manner into whatever number of parts the line AB is divided. Therefore the direct ratio's may be well substituted in the place of the reciprocal: for it is evident, they are the same considered in a different manner; this is true not only in ratio's directly or reciprocally as the distances, but in ratio's likewise as the cubes or squares of the distances, and in any series of decreasing or increasing ratio's; for the same are increasing ratio's, if the smallest term be the first and be made unity, which
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are decreasing when the greatest term is put first, or made unity, and thereby becomes reciprocal to the former.

58. If two equal spherical bodies be placed within the distance, to which the actions of the resisting matter in each extend, or within each other's spheres of attraction; the æther will have its elasticity lessened by both, in a ratio reciprocal to the cubes of the distances from each, as in the margin.

Let there be two quantities of resisting matter, whose force or action on the contiguous surface of æther in each, is equal to 1240, and that these two bodies are placed at the extremity of each other's spheres of attraction; then the æther between these two bodies must have its elasticity lessened, in a ratio reciprocal to the cubes of the distances of each, or in the order and ratio of the numbers 1240, 1015, 819, &c. in the two first lines of numbers; and the elasticity of the æther is lessened by the action of both these bodies,

1240,	1015,	819,	650,	506,	385,	285,	204,	140,	91,	55,	30,	14,	5,	1,
1,	5,	14,	30,	55,	91,	140,	204,	285,	385,	506,	650,	819,	1015,	1240,
1241,	1020,	833,	680,	561,	476,	425,	408,	425,	476,	561,	680,	833,	1020,	1241,
1020,	833,	680,	561,	476,	425,	408,	425,	476,	561,	680,	833,	1020,	1241,	1240,
221,	187,	153,	119,	85,	51,	17,	17,	51,	85,	119,	153,	187,	221,	221,
187,	153,	119,	85,	51,	17,	17,	51,	85,	119,	153,	187,	221,	221,	187,
34,	34,	34,	34,	34,	34,	34,	34,	34,	34,	34,	34,	34,	34,	34,

as the sums of the terms of these two lines of numbers, or as the numbers 1241, 1020, 833, &c. in the third line of numbers: but the sums of the terms of two equal opposite progressions, each increasing the contrary way, as the cubes of the distances, are as the squares of the distances from the middle point; and the differences between these terms increasing as the squares of the distances are directly as the distances, or as 221, 187 in the fifth line, or are arithmetical proportionals.

59. The greatest force of the elasticity of the æther between two equal bodies, is in the middle point between them: for the sum of the terms of two oppositely decreasing equal progressions, continually decrease to that point from the greatest point of each progression; and the sum of the terms in this case, is the ratio in which the elasticity of the æther is lessened: therefore a third small body, placed any where between this middle point and either of the bodies, must be repelled and gravitate towards that body. But it is to be observed, that such third bodies can only gravitate towards either of the other two, which have their absolute force of attraction less than that compound force at the distance at which the third body is placed: for if the absolute force be greater, they will likewise attract the other, and a small body placed exactly in the middle between two equal large bodies, will remain at rest.

60. This

60. This middle point between equal bodies, is called the *Limit* of their several attractions: and to find the limit of attraction between unequal bodies; which by any force are kept at the same distance; first find the distance from the greater body, at which the force of its attraction is equal to the absolute force of the less body; then if the smaller body be placed nearer to the greater, or at that distance, there is no attraction to the smaller body; but if it be placed further from the greater body than this distance, then the middle distance between the smaller body and this distance, is the limit of attraction between the two unequal bodies: for from that place where the force of attraction of the greater body, is equal to the absolute force of attraction of the smaller body, the elasticity of the æther in the space between this place and the smaller body, is lessened in the same manner as between equal bodies.

61. If two bodies, a greater and a smaller, be so placed, that the attraction of the greater body, at the distance at which the smaller is placed, be greater than the absolute force of the smaller, then this smaller body cannot attract a third body, placed any where between them; but if the smaller body be removed to a greater distance, then a third little body may be so placed between them, as to be attracted by the smaller body, and the distance at which the smaller body can attract a third, will always increase as its

distance from the greater body increases. This may be of use to explain many phenomena among small or little bodies, where the distance between them is continually changing, or is by some force or other changed.

62. If two spherical bodies be retained by any force within the spheres of each other's attraction, at the same distance, such as that a third body at some distance or other may be attracted to either one of them; and that a surface be so extended from the limit of their spherical attractions, in the line connecting their centers, that the ratio of the distances of every point in that surface to the two bodies be the same, as the ratio of the distance of the limit of attraction in the line connecting their centers to the same bodies; then a third little body placed any where from the point of limit in this surface, will be attracted towards this point of limit: and if the little body be placed any where out of this surface on either side of the line connecting the centers of the greater bodies, the little body will be attracted towards that of the two greater bodies, between which and that surface it is placed: but this little body will not move in a strait line to the center of that body, but in a curve line, whose curvature continually decreases as it approaches to that body. This paragraph is to be understood with this limitation, that the third little body be placed

placed in the surface extended from the point of limit, so as to be in some sense really between the two great bodies; that is, so as that a line from the center of the third little body drawn to the center of the greatest, do not intersect that surface.

63. Therefore if two unequal bodies be kept at the same distance, a little body nowhere gravitates to the center of gravity of these two bodies.

64. If two spherical bodies be so far placed within the sphere of each other's attraction, that it extends beyond the other body; then the force of gravitation of a third little body to either one of them, while in the line passing through the centers of the two bodies, is reciprocally as the distance from that body to which it gravitates, or directly as the distance from the limit, while it is between the two bodies, but reciprocally as the squares of the distances, when on the other side of either of them: the force of attraction of each of these two bodies on the opposite side to each other, is increased in the same manner, as if their quantity were increased by a quantity of resisting matter, equal to the force of the other at the distance at which the other is placed. Thus supposing the absolute force of each of these two bodies to be 1240, and that the bodies were placed within the sphere of each other's attraction, as these numbers are in the

example in the margin; where the first and

1015,	1240,	1015,	819,	650,	506,	385,	285,	204,	440,	191,	55,	30,	14,	5,
91,	140,	204,	285,	385,	506,	650,	819,	1015,	1240,	1015,	819,	650,	506,	385,
1106,	1380,	1219,	1104,	1035,	1012,	1035,	1104,	1219,	1380,	1106,	874,	680,	520,	390,
1380,	1219,	1104,	1035,	1012,	1035,	1104,	1219,	1380,	1106,	874,	680,	520,	390,	286,
274,	161,	115,	69,	23,	23,	69,	115,	161,	274,	232,	194,	160,	130,	104,
115,	69,	23,	23,	23,	23,	69,	115,	161,	274,	232,	194,	160,	130,	104,
40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,
40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,	40,

second lines of numbers are as the separate forces of these two bodies, at the several distances; the third line is as their united force at the same distances; and the lines under it shew the differences between the terms of this united force, and the force wherewith a third body gravitates to either of them.

65. But in a circle drawn from one body, as a center through the center of the other, the force of the æther increases reciprocally, as the cubes of the distances from the body through which the circle passes, but is at all these distances further lessened equally, by the force of the central body at that distance. Thus in the example in the margin, the force of the central body on the body through

thro' which the circle passes, is 140, and therefore their united force there is $1240 + 140 = 1380$, and at several distances from this body equidistant from the other, it is, $1015 + 140 = 1155$, $819 + 140 = 959$, $650 + 140 = 790$, &c. then the force of gravitation in this circle to the body through which it passes, is the same every where, that it would be to that body were it placed singly by itself; because the differences between the terms, are in both cases the same.

66. It is likewise evident from the numbers in 58 and 64, that the differences of the elasticity of the æther in the line passing through the centers of two bodies, placed within the sphere of each others attraction, are different from what they are when either of the bodies are placed single; and if they remove from each other, decrease in the space between these bodies reciprocally, as the cubes of the distances of the other from that body: for these differences are made by a continual addition of the cubes of an arithmetical progression; and therefore, that the differences of the force of attraction in the same cases decrease reciprocally, as the squares of the same distances: for the differences of differences increasing as the cubes are as the squares. But since the differences of the elasticity of the æther in the same line, but on the other sides of these bodies, increase reciprocally, as the cubes of the distances in the same case; the difference of the force of attraction will be reciprocally,

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as the squares of the distances from either body: therefore, as two bodies approach to each other, the force of their attraction in the line passing through their centers, decreases in the space between them reciprocally, as the squares of their distances; but on the other side of them increases reciprocally as the squares of their distances.

67. Hence the gravitation of the moon in one half of her orbit, from the quadratures to the opposition, and from the opposition to the opposite quadrature is increased everywhere reciprocally, as the squares of the earth's distance from the sun; but in the other half of her orbit, her gravitation is decreased everywhere reciprocally, as the squares of the earth's distance from the sun: and the moon gravitates in her conjunctions, towards either the sun or the earth, not reciprocally to the squares of the distances, but reciprocally to the distances themselves.

68. I shall, in the last place, apply this theory of the æther and of gravitation to a most remarkable phenomenon, which puzzled all the philosophers till sir ISAAC NEWTON explained it; I mean, the tides of the sea. Any fluid on the surface of the earth will be less pressed in the places (and near them) where the surface is cut by a line passing thro' the centers of the moon and earth, than where the surface is cut by a plain perpendicular to that line, and passing thro' the center of the earth; for the elasticity of the æther being
every

every where equally lessened, on the surface of any spherical body, by the resisting matter of that body, there can be no difference occasioned by it, in any part of the surface: but the elasticity of the æther at the surface of the earth next the moon, is more lessened by the resisting matter in the moon, than at the distance of the earth's center from the moon, and more at the center than at the surface farthest from the moon: but of any three terms of a progression, increasing as the cubes of arithmetical proportionals, twice the middle term is less than the sum of the first and third term; therefore, the two opposite surfaces of the earth, cut by a line passing thro' the centers of the earth and moon, will be less pressed than any two opposite surfaces of the earth, cut by a plain perpendicular to that line, and passing thro' the center of the earth; and if by any means the pressure of the æther on the opposite sides of a spherical body be unequal, (47) it must become on each side equal to half the sum of the pressure of both the opposite sides, by the point of equal pressure, in the body when single, being moved in the line connecting the centers of the two bodies towards the side which is least pressed. This perhaps may appear more plainly, by observing the ratio's of elasticity of the æther in Par. 64, 65, thus:

1035	1104	1219	1380	1106	874	680
69	115	161	274	232	194	
790	959	1155	1380	1155	959	790
169	196	225	225	196	169	

where the first line of numbers shews the ratio of elasticity of the æther on both sides of one of the bodies, and which at the distance of its center from the other body is = 1380, and at every two equal distances from the center, are $1219 + 1106 = 2325$, $1104 + 874 = 1978$, $1035 + 680 = 1715$. The second line shews the differences of the elasticity of the æther on each side of the same body, in equal distances in that line, or the ratio of gravitation, *viz.* $161 + 274 = 435$, $115 + 232 = 347$, $69 + 194 = 263$. The third line shews the ratio of elasticity at the same distances in the spherical surface, every where equally distant from the center of the other body, where $1155 + 1155 = 2310$, $959 + 959 = 1918$, $790 + 790 = 1580$. And the last line shews the ratio of gravitation in the same spherical surface, and at the same distances $225 + 225 = 450$, $196 + 196 = 392$, $169 + 169 = 338$. Now 2325 is greater than 2310, 1978 is greater than 1918, and 1715 is greater than 1580: therefore the elasticity of the æther is more lessened in the line connecting the centers of two bodies, than in the spherical surface in parts æquidistant from the other body. Again, 435 is less than 450, 347 is less than 392, and 263 than 338, or the ratio or force of gravitation is al-

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ways greater at the same distances in the spherical surface, every where æquidistant from the other body, than in the line connecting the centers of the two bodies; and in distances near the center of the body thro' which this spherical surface passes, it coincides with a plain normal to the line passing thro' the centers of the two bodies.

So far as I have now gone, I think sufficient to shew the agreement of this theory with several general phenomena, and may serve to shew the method of applying it to others, and to the peculiarities of particular cases, when any shall think proper to take the trouble of doing it. I am perswaded, it might have been put into a strictly mathematical demonstrative method, by separating the *definitions*, *axioms*, and *lemmata* from other sciences into their proper order, and by deducing the theorems from thence; but I was of opinion, that the method which I have taken, is more proper for conveying new conceptions, and such as have not been before received: neither could that method have been pursued within the compass I had set to myself. Besides, I believe, that the evidence of the truth of it is much stronger, by shewing its agreement with nature in every instance, than by the most pompous demonstration: for how often have the greatest men erred in their deductions in this method. For this reason, I had a strong inclination to have shewed the

conformity of this theory with the motion of the planets, by shewing in the phænomena of their motion, the force and ratio of the *moving power*; and likewise in many phænomena observed by sir ISAAC NEWTON, in his Optics, by which, I think, I might have illustrated many things not touched in sir ISAAC's theory; and more particularly to have given (if I be not much deceived) a new theory of the moon; but I have too good reason to conclude, that in my present circumstances I shall never be able to accomplish it. I thought, however, it may be of some use to give these hints to the learned, which I have been able in some measure to digest, that thereby others, more capable than myself, may improve them to the benefit of the publick. Sir ISAAC has taken wonderful pains, and many of his followers since have been indefatigable in applying his theory of the moon to practice; but after all, I do not find that they have been able to form tables so useful in practice as was expected, and which in all cases agree with observation: I may therefore be allowed to suspect, that his theory is in some measure defective.

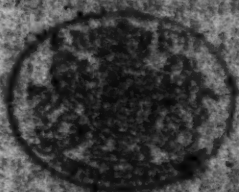
Since these sheets were sent to the press, I obtain'd mr. *Flamsteed's Historia cælestis*; and as one great advantage of the doctrine above deliver'd, is, that it gives an easy and certain method of forming equations for the planets motions and orbits; which by all other methods, which I have seen, seems to be very difficult

difficult and perplexing: I form'd equations for the earth, so far as to assure my self, by several calculations in different parts of her orbit, that this theory agrees with the phænomena to as great an exactness as I expected. If I be not much mistaken, this theory and mr. *Flamsteed*'s observations, will mutually prove the accuracy of each other. I have fallen (I think) on a method in proving this, independent of refractions and of the latitude, different from that which mr. *Flamsteed* takes in his prolegomena, and which has one advantage above his, that it is less complicated, requires fewer *data* or things to be known, and consequently is less subject to error.

Some thoughts may have occurred to my imagination in thinking so long as I have already on this subject, which may not readily to men of more skill and knowledge. *Si Deus nobis hæc otia fecerit*, that I could be enabled to digest into order, and demonstrate these thoughts without prejudice, or rather with some advantage to those cares which every man ought to have near his heart, and which speculative studies are apt to make him neglect; I should think it the greatest happiness that can befall me in the last stage of my life, to be thus useful with the greatest pleasure to my self.

*Namque erit ille mihi semper Deus: illius aram
Sæpe tener nostris ab ovilibus imbuet agnus.*

F I N I S.



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